The Future of Transportation in Illinois: Depopulation, Impacts of COVID-19, and Integration with other Infrastructure Systems

Derrible, Sybil (derrible@uic.edu)

Complex and Sustainable Urban Networks (CSUN) Lab
Civil and Materials Engineering, University of Illinois at Chicago, USA
Institute for Environmental Science and Policy, University of Illinois at Chicago, USA
Computer Science, University of Illinois at Chicago, USA

Agenda

1. Depopulation in Illinois
2. Impact of COVID-19
3. Integration with other infrastructure

Depopulation

Depopulation

Objectives

1. Identify and cluster depopulating cities (completed)
2. Survey depopulating cities (in progress)
3. Forecast impact of depopulation in Illinois (in progress)
4. Organize a forum at UIC, inviting officials from cities that are facing depopulation, to discuss challenges and solutions (future)
5. Sharing all information and models developed openly (future)

Identify and Cluster Depopulating Cities

Identify Depopulating Cities

- Depopulation is defined as “chronic population loss.”

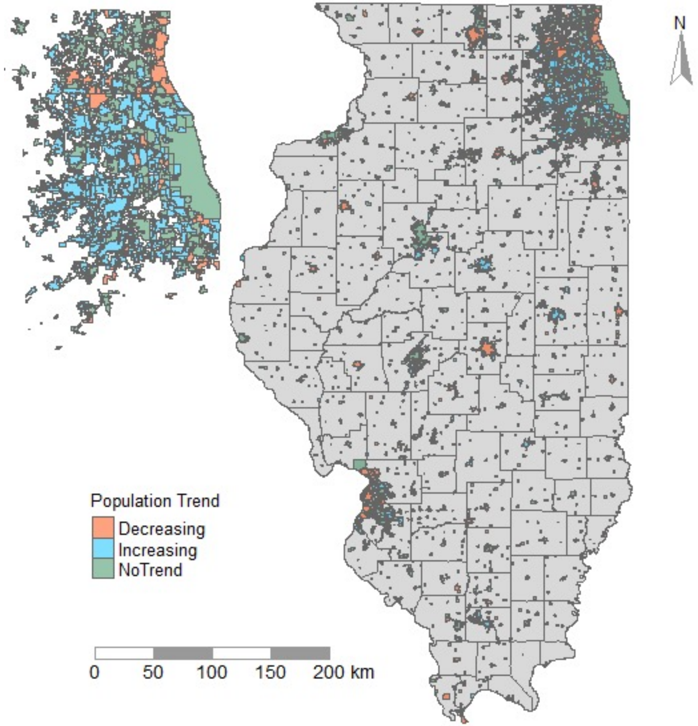
- Using ACS data, we collected population data from 2009 to 2017 and used Mann-Kendall (MK) test.

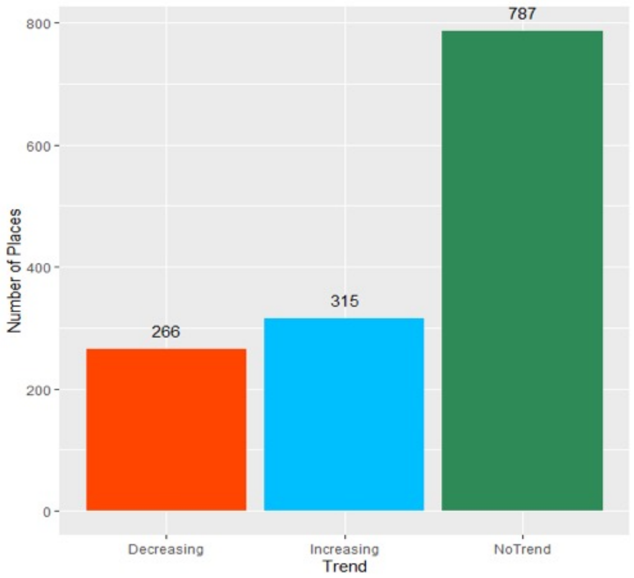
- Focus on “places” as defined by the Census Bureau.
    - Smaller than counties but larger than zip codes.
    - Includes municipalities, villages, and boroughs.

  -> refer to them as “cities” from now on.

Identify Depopulating Cities

- Out of 1,368 places in Illinois, 266 were found to be depopulating.





Cluster Depopulating Cities

- Manually select variables that seem relevant from Census (not relevant to depopulation but to clustering cities)

  -> Found 58 variables.

Cluster Depopulating Cities

Dimension	Variables	Categories: Values are in %.
Social	Language	English only Spanish only Spanish and English Other languages
	Household Structure	Families, Non-Families.
	Uninsured	Age: Under 19, Age: 19 – 34, Age: 35 – 54, Age: 55 – 74, Age: Above 75.
		Uninsured percentage
	Employment	Male: Work in same county, Male: Work in different county, Female: Work in same county, Female: Work in different county.
	Unemployment	Unemployment percentage

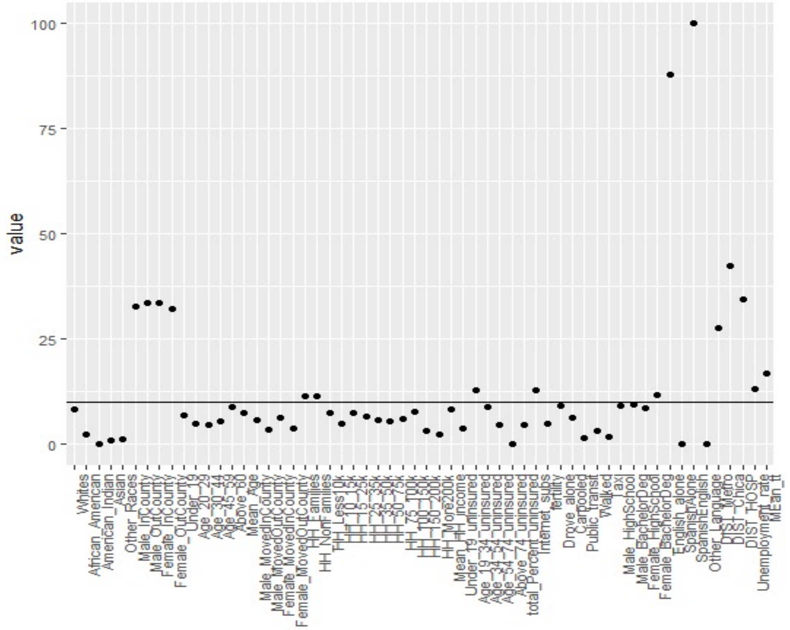
Dimension	Variables	Categories: Values are in %.
Demo-graphic	Age	Mean Age
		Under 19, 20 – 29, 30 – 44, 45 – 59, Above 60.
	Household Income	Mean Income
		Less than 10000, 10000 – 15000, 15000 – 25000, 25000 – 35000, 35000 – 50000, 50000 – 75000, 75000 – 100000, 100000 – 150000, 150000 – 200000, More than 200000.
	Race	Whites, African American, American Indian, Asian, Other races.
	Education	Male: High School Diploma, Male: Bachelor's or Higher Deg, Female: High School Diploma, Female: Bachelor's or Higher Deg.

Dimension	Variables	Categories: Values are in %.
Technology	Internet Subscription	Household with Internet subscription.
Transportation	Travel time	Mean commuting time to work
	Mode of transportation to work	Drove alone, Carpooled, Walked, Taxi, Public Transit
Others	Fertility	Women gave birth in the last 12 months
	Recently moved to other places	Male: within county, Male: to a different county, Female: within county, Female: to a different county.
Distance	Distance to Chicago	Distance values are standardized by its maximum value
	To the nearest Hospital	
	Distance to Metropolitan	

Cluster Depopulating Cities

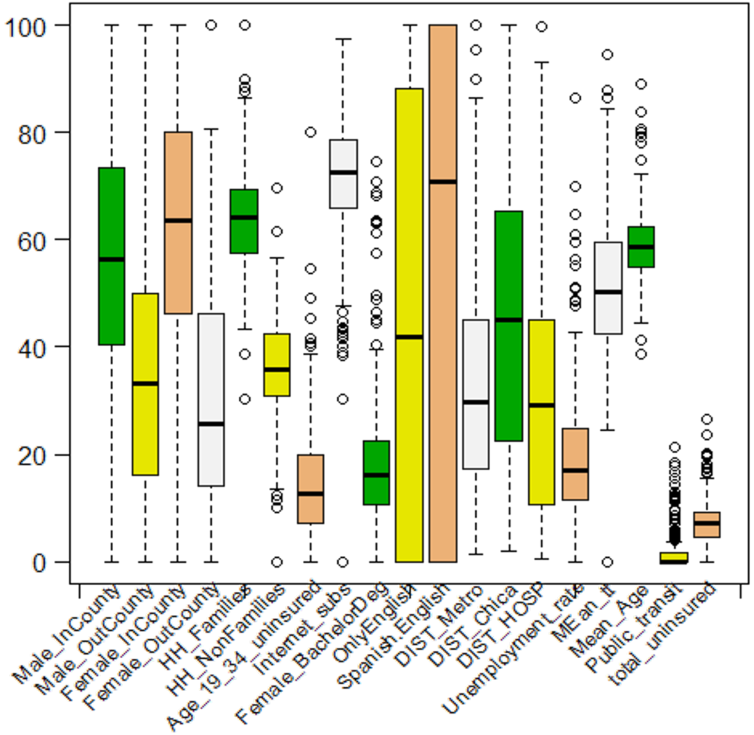
- Remove variables that do not vary significantly across cities if Inter-Quartile Range (IQR) < 10.

- Result in 16 variables to which we added 3 that we thought were significant.



Cluster Depopulating Cities

- Result in 16 variables to which we added 3 that we thought were significant.



Cluster Depopulating Cities

Dimension	Variables	Categories: Values are in %.
Social	Language	English only Spanish and English
	Household Structure	Families, Non-Families.
	Uninsured	Age: 19 – 34,
		Uninsured percentage
	Employment	Male: Work in same county, Male: Work in different county, Female: Work in same county, Female: Work in different county.
	Unemployment	Unemployment percentage

Dimension	Variables	Categories: Values are in %.
Demo-graphic	Age	Mean Age
	Household Income	Mean Income
	Education	Female: Bachelor's or Higher Deg.

Dimension	Variables	Categories: Values are in %.
Technology	Internet Subscription	Household with Internet subscription.
	Mode of transportation to work	Public Transit
Distance	Distance to Chicago	Distance values are standardized by its maximum value
	To the nearest Hospital	
	Distance to Metropolitan	

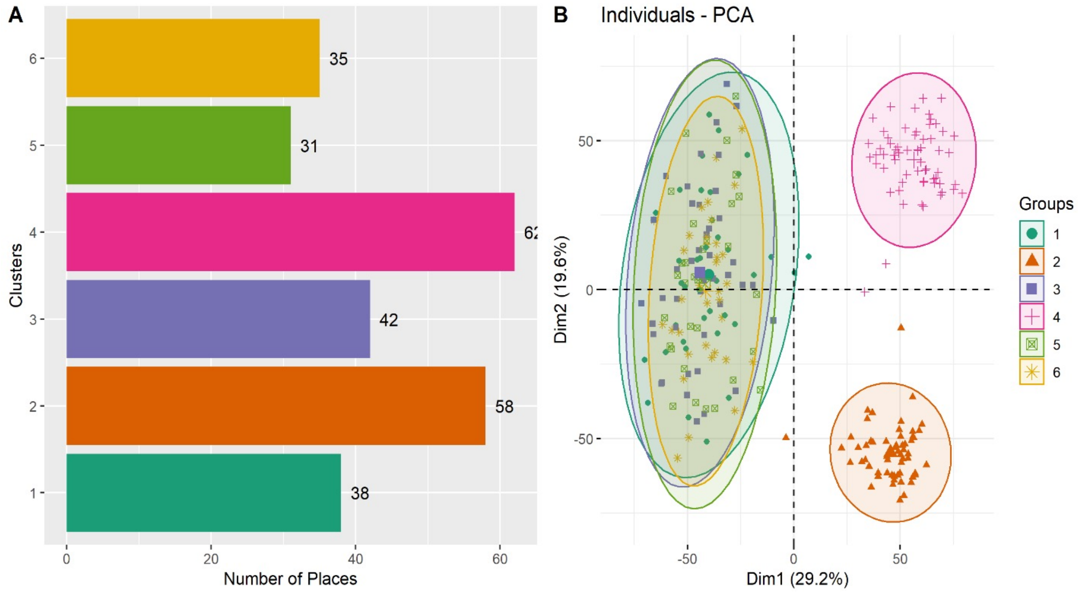
Cluster Depopulating Cities

- Fuzzy C-Means (FCM) clustering.

- Evaluated with silhouette score.

- Plotted results using PCA.

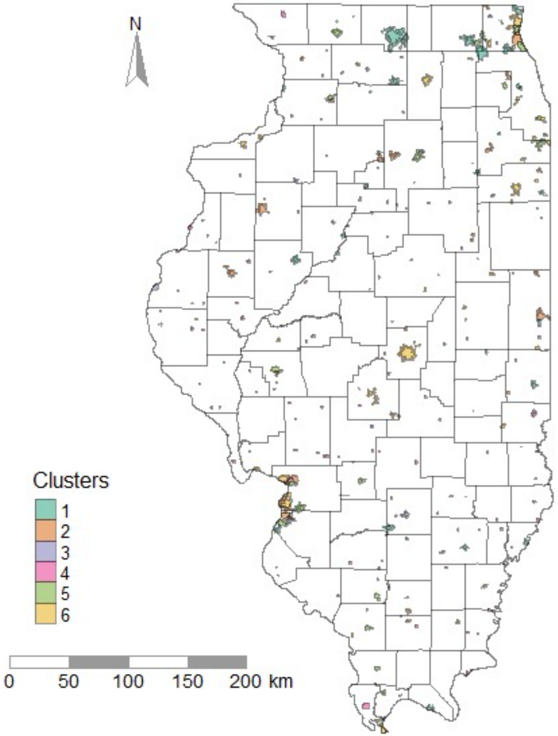
- Found **six** clusters.



Cluster Depopulating Cities

Clusters	Variables	Characteristics
Cluster 1	Unemployment rate	Around 24 % of the cities has **UR exceeds 30%.**
	Internet subscription	Cities in this cluster have **highest mean average internet subscription**.
	Distance to Hospitals	More cities in this cluster have **hospitals nearby**.
Cluster 2	Average age of population	56% of the cities in this cluster have population with **age above 60**. Meaning, this cluster has relatively higher older population.
	Average Household Income	Cities with **lowest mean household income**.
	Distance to Chicago	**Average distance to Chicago is higher** for cities in this cluster.
Cluster 3	Average commuting time	21.4% of cities in this cluster have **average commuting time of 65 minutes or longer**.
	Distance to Metropolitan areas	Cities that are **closest to a metropolitan area**.
	Minorities	Has the **highest average percentage of minorities** living in these cities.
	Distance to Chicago	Cities in this cluster are relatively **closer to Chicago**.
Cluster 4	Language	Cities in this cluster has, on average, the **highest percentage of people who speak Spanish alone** (52%).
	Income bracket: 75 to 100K with average percentage of population in this bracket is 12%	Highest number of cities (24%) in this cluster have more than **18% of population in this income bracket**.
	Distance to Hospital	Cities in this cluster, on average, have **longer distance to hospitals**.
Cluster 5	Average commuting time	Highest number of cities (25%) with **commuting time less than 40 minutes**.
	Family	This cluster, on average, has the **highest percentage of people who does not live with family**.
	Age	On average, this cluster has cities with **highest percentage of people aged between 20 and 29**.
Cluster 6	Education	Highest number of cities (20%) that have **more than 30% of female with bachelor's degree**.
	Transportation means to work	On average, this cluster has cities with **highest percentage of people who walked to work**.

Clusters



Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Bensenville village.	Alsey village.	Alton city.	Arrowsmith village.	Buffalo Grove village.	Armington village.
Bethalto village.	Annapolis CDP.	Anna city.	Ashland village.	Casey city.	Barrington Hills village.
Bondville village.	Apple Canyon Lake CDP.	Braceville village.	Augusta village.	Chatsworth town.	Beaverville village.
Cahokia village.	Basco village.	Bulpitt village.	Belgium village.	Cherry Valley village.	Bement village.
Carmi city.	Batchtown village.	Cairo city.	Blue Mound village.	Crete village.	Canton city.
Cary village.	Belle Prairie City town.	Carbon Hill village.	Centreville city.	Decatur city.	Carbon Cliff village.
Cedarville village.	Bellmont village.	Centralia city.	Cornell village.	Freeport city.	Cisne village.
Central City village.	Bingham village.	Danville city.	Dayton CDP.	Galesburg city.	Crystal Lake city.
Channel Lake CDP.	Bowen village.	DeKalb city.	Donovan village.	Gladstone village.	Dix village.
Chebanse village.	Bushnell city.	Dixmoor village.	Du Bois village.	Golden village.	Dupo village.
Collinsville city.	Camp Point village.	Dolton village.	Dunlap village.	Greenville city.	East St. Louis city.
Dana village.	Clayton village.	Du Quoin city.	Elizabethtown village.	Ingalls Park CDP.	Forest Park village.
Eldorado city.	Donnellson village.	Elwood village.	Erie village.	Kankakee city.	Granite City city.
Fairfield city.	East Alton village.	Fulton city.	Exeter village.	Kansas village.	Granville village.
Ford Heights village.	El Dara village.	Gorham village.	Fieldon village.	Madison city.	Hodgkins village.
Godley village.	Equality village.	Grant Park village.	Findlay village.	Metropolis city.	Hoopeston city.
Grafton city.	Fillmore village.	Henry city.	Forest Lake CDP.	North Barrington village.	Island Lake village.
Lake Forest city.	Flat Rock village.	Highland Park city.	Fox Lake Hills CDP.	Pana city.	Jacksonville city.
Maywood village.	Freeman Spur village.	Hopkins Park village.	Franklin Grove village.	Paw Paw village.	Lawrenceville city.
Melvin village.	Fults village.	Johnston City city.	Galva city.	Peoria Heights village.	Macomb city.
Milan village.	Goofy Ridge CDP.	LaSalle city.	Georgetown city.	Radom village.	Mount Carroll city.
Mount Carmel city.	Gulf Port village.	Ladd village.	Girard city.	Rankin village.	Mount Morris village.
Murphysboro city.	Hamburg village.	Lake Bluff village.	Hanover village.	Rock Falls city.	North Chicago city.
Naplate village.	Henderson village.	Lake of the Woods CDP.	Herscher village.	Secor village.	Ottawa city.
North Pekin village.	Hettick village.	Le Roy city.	Hume village.	Sheffield village.	Peotone village.
Paris city.	Jeisyville village.	Maroa city.	Hutsonville village.	Smithfield village.	Perry village.
Paxton city.	Kenney village.	McCook village.	Junction village.	South Jacksonville village.	Pierron village.
Percy village.	Littleton village.	Milledgeville village.	Kangley village.	Vergennes village.	Pleasant Hill village.
Port Barrington village.	Louisville village.	Millington village.	Kempton village.	Virginia city.	Riverwoods village.
Rochelle city.	Marshall city.	Momence city.	Kinsman village.	West City village.	Rockford city.
Stanford village.	Mill Creek village.	Park Forest village.	Lacon city.	Zion city.	Sleepy Hollow village.
Sterling city.	Mount Erie village.	Ridge Farm village.	Lake Petersburg CDP.		Steger village.
Ullin village.	Mount Olive city.	Riverdale village.	Lerna village.		Ursa village.
Villa Park village.	Nebo village.	Shannon village.	Lima village.		Villa Grove city.
Viola village.	New Haven village.	Spring Valley city.	Lynnville village.		Washington Park village.
White City village.	Niantic village.	Taylorville city.	Maeystown village.		
Willowbrook CDP.	Oakdale village.	Third Lake village.	Monroe Center village.		
Xenia village.	Odin village.	Tilton village.	Mound City city.		
	Old Shawneetown village.	Toluca city.	Mount Clare village.		
	Olive Branch CDP.	Waukegan city.	Murrayville village.		
	Palmer village.	West Frankfort city.	New Grand Chain village.		
	Parkersburg village.	Wood River city.	Nokomis city.		
	Pittsburg village.		Odell village.		
	Pontoosuc village.		Oreana village.		
	Raritan village.		Oregon city.		
	Rock City village.		Patoka village.		
	Rose Hill village.		Polo city.		
	Rosiclare city.		Rutland village.		
	Rushville city.		Sadorus village.		
	Sailor Springs village.		Salem city.		
	Scottville village.		Shipman town.	Tower Lakes village.	
	St. Elmo city.		Spring Bay village.	Warsaw city.	
	St. Francisville city.		Stronghurst village.	Washburn village.	
	Strasburg village.		Tallula village.	Wayne City village.	
	Strawn village.	Walshville village.	Tampico village.	West Salem village.	
	Tamaroa village.	Woodson village.	Towanda village.	Williamsfield village.	

Survey Depopulating Cities

Survey Depopulating Cities

- Survey developed.
- Initial screening completed.
- Coding survey into Qualtrics completed.
- Pilot survey (in progress)
- Seek IRB exemption (in progress)

Survey Depopulating Cities

- Questions related to mobility challenges and opportunities:
  - Access to car
  - Access to transit and coordination between agencies
  - Presence of TNCs (e.g., Uber, Lyft)
  - Main challenges by mode (e.g., fuel costs, service frequency)
  - Solution identification (e.g., road maintenance, extended service)
  - Impact on people with physical disabilities
  - …

Survey Depopulating Cities

Contact me:
derrible@uic.edu

Impact of COVID-19

COVID-19 Future Survey

The 'COVID Future Panel Survey' is nationwide online panel survey that collects the information on attitudinal and behavioral changes before, during, and after the pandemic.

The survey asked questions about commuting, daily travel, air travel, working from home, online learning, shopping, and risk perception, along with attitudinal, socioeconomic, and demographic information.

The survey data was properly weighed and cleaned and shared publicly on ASU Dataverse.

The project was funded by the NSF RAPID Award 2030156.

COVID-19 Future Survey

The survey was conducted in multiple waves, by reaching out to the same respondents over time.

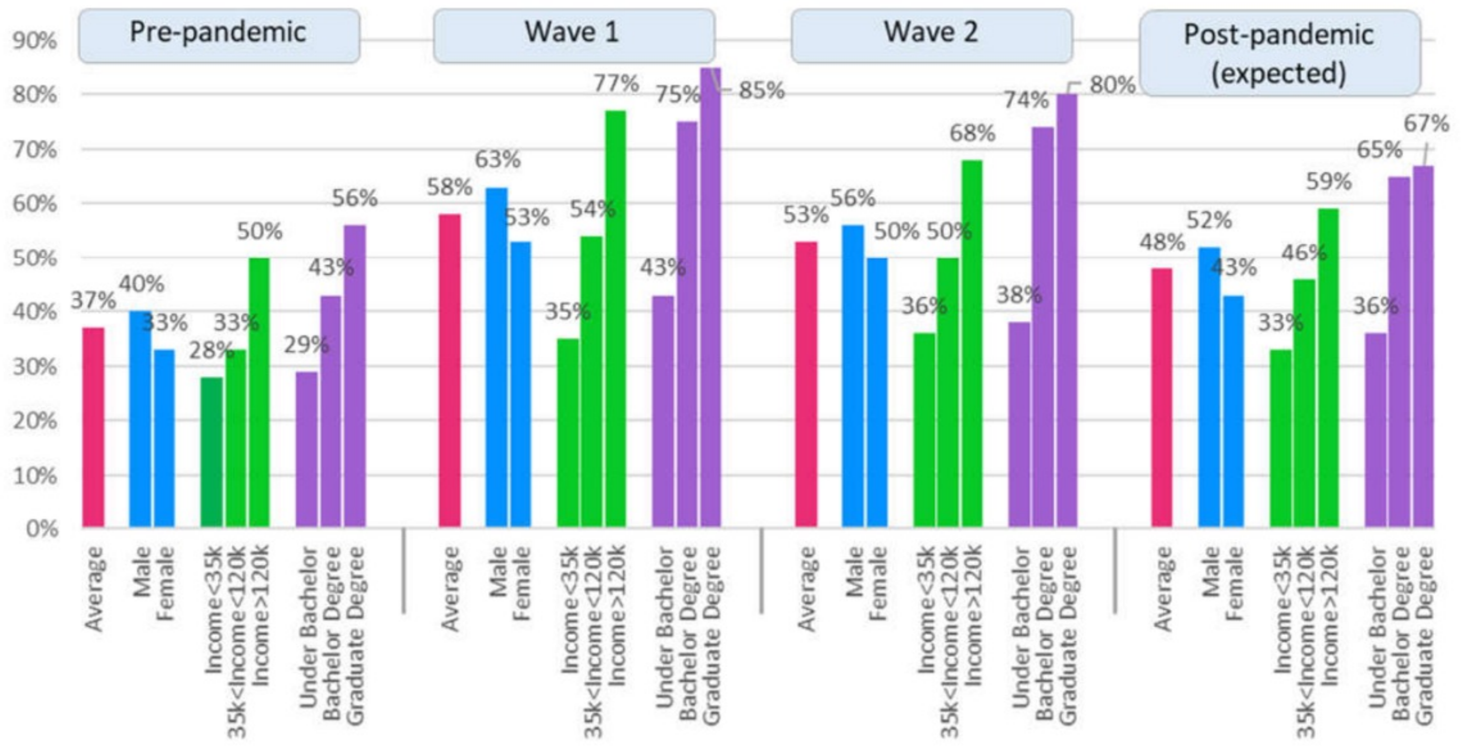
The Wave 1 of the survey was conducted from April 2020 to October 2020; Wave 2 from November 2020 to May 2021; and Wave 3 started in October 2021 and is ongoing.

The total responses in wave 1 were 8,723 and that in wave 2 were 2,973.

For more information about the survey, please visit covidfuture.org.

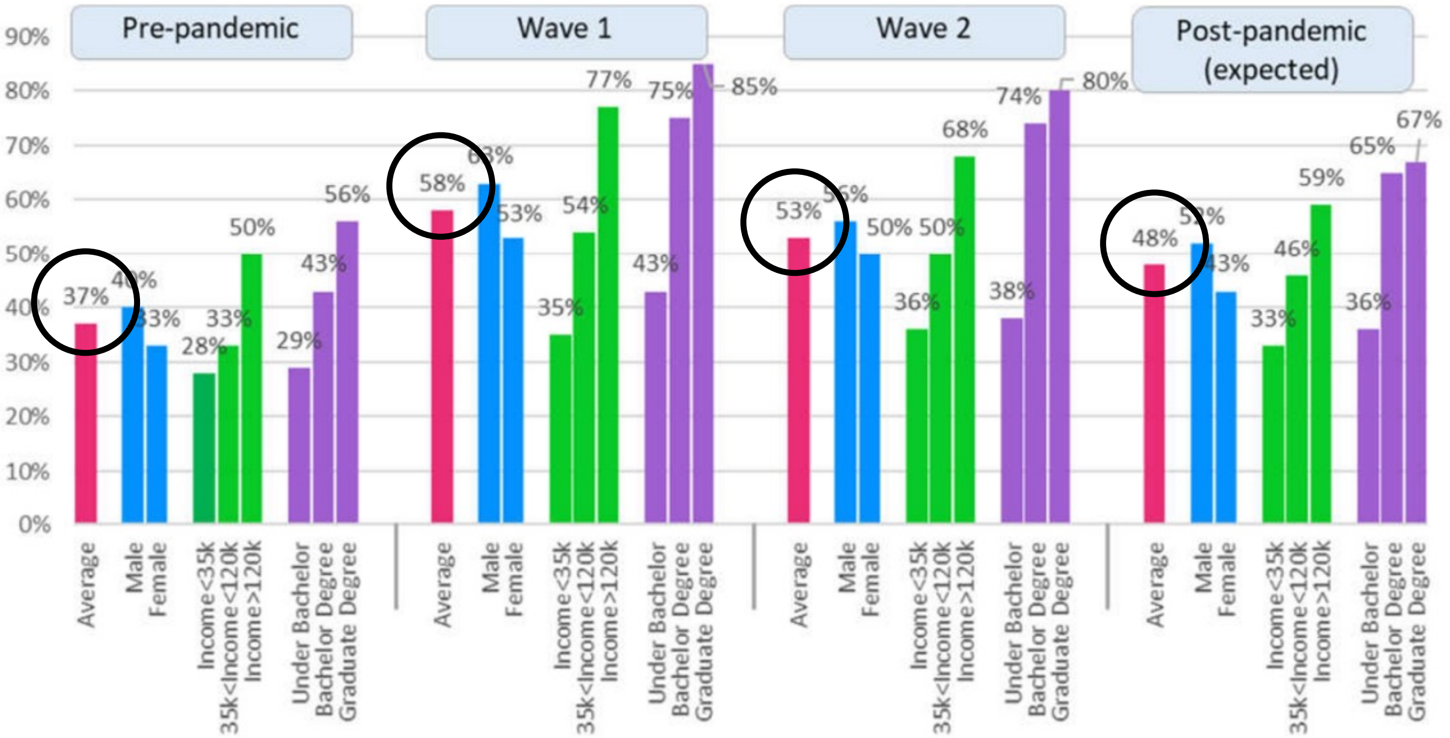
Telecommuting

Telecommuting



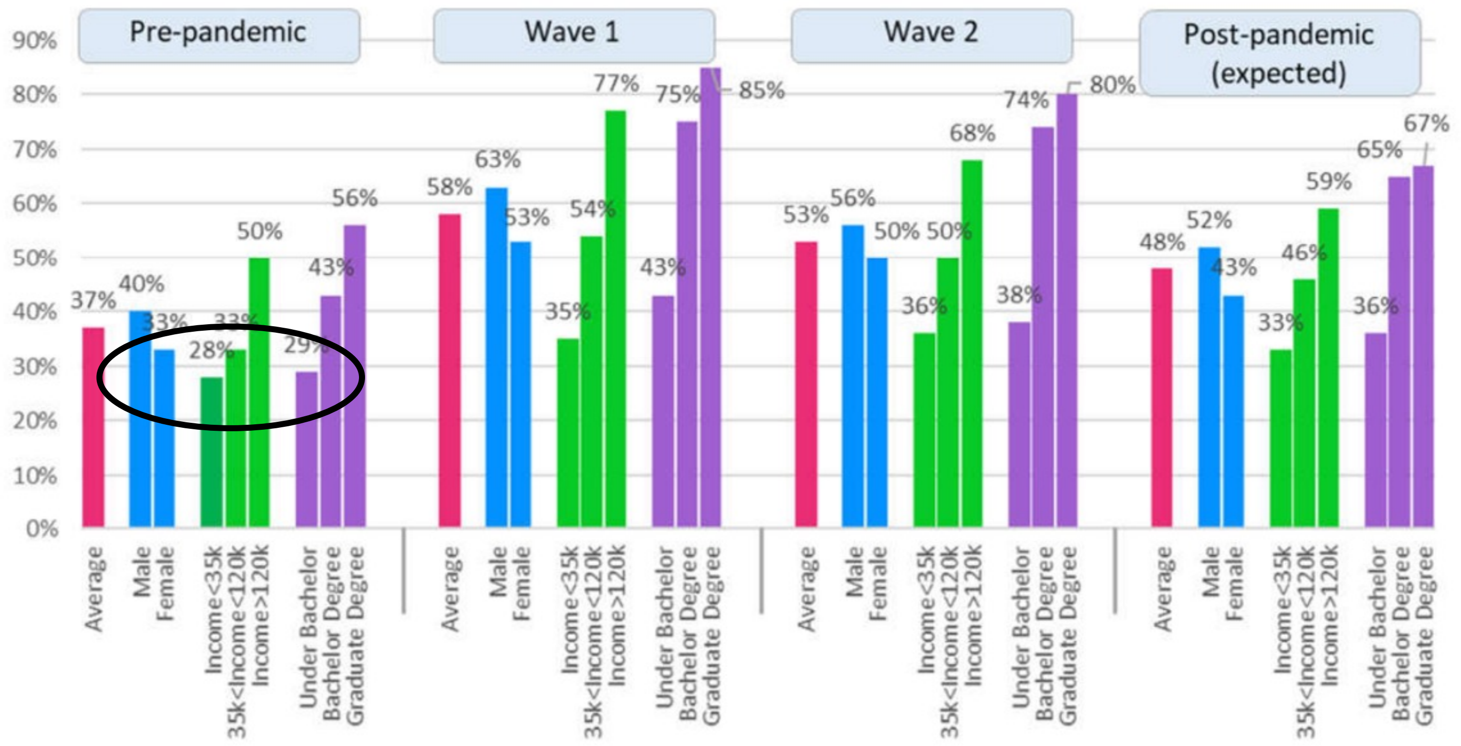
Workers who have not been laid off during the pandemic were asked if they have the option to telecommute?

Telecommuting



Through the pandemic, there has been an increase in the percentage of respondents who have the option to telecommute. A large percentage of people also expect to be able to telecommute after the pandemic.

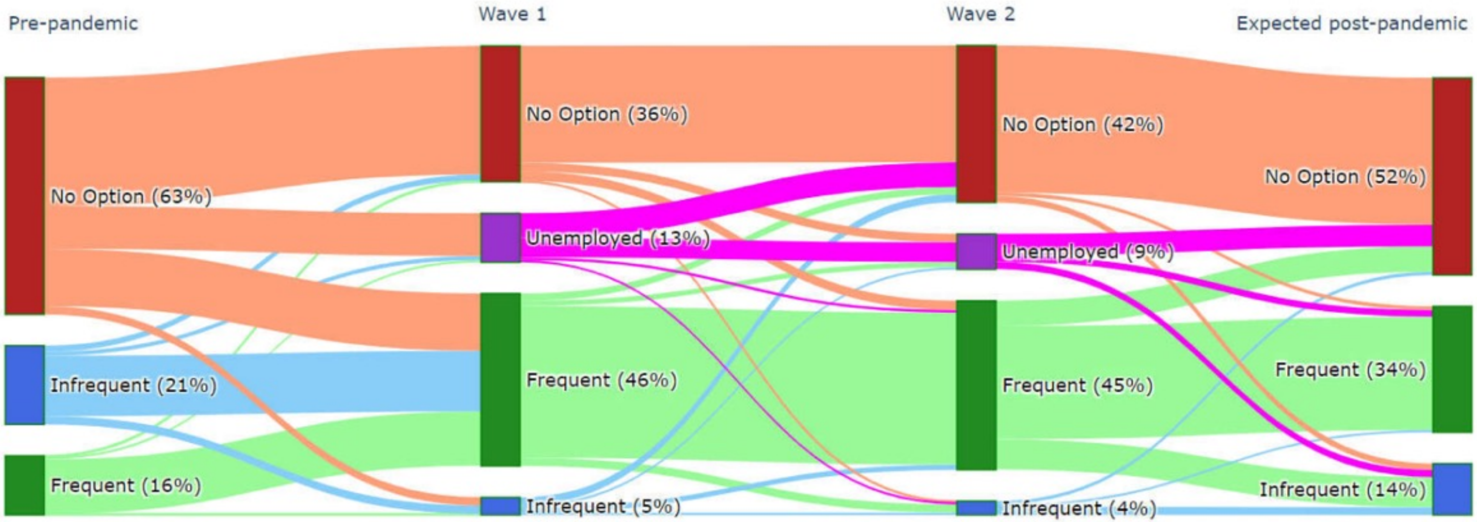
Telecommuting



Following have below average proportion with option to telecommute:

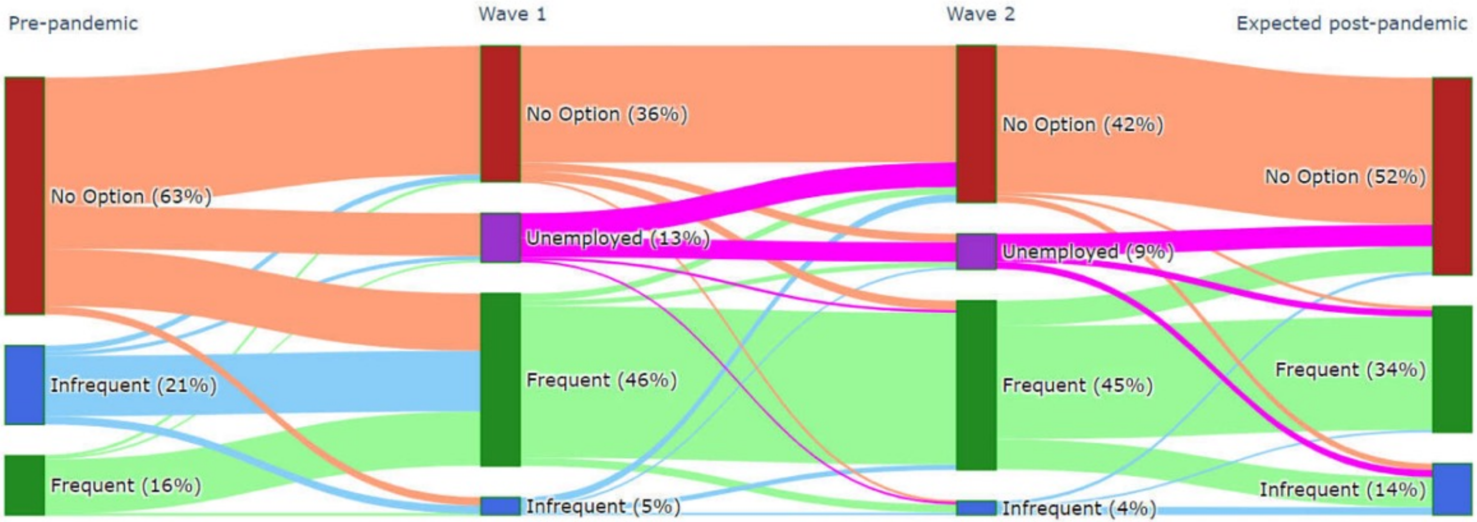
- Females
- Household income less than 120 K
- Education less than Bachelor's degree.

Telecommuting



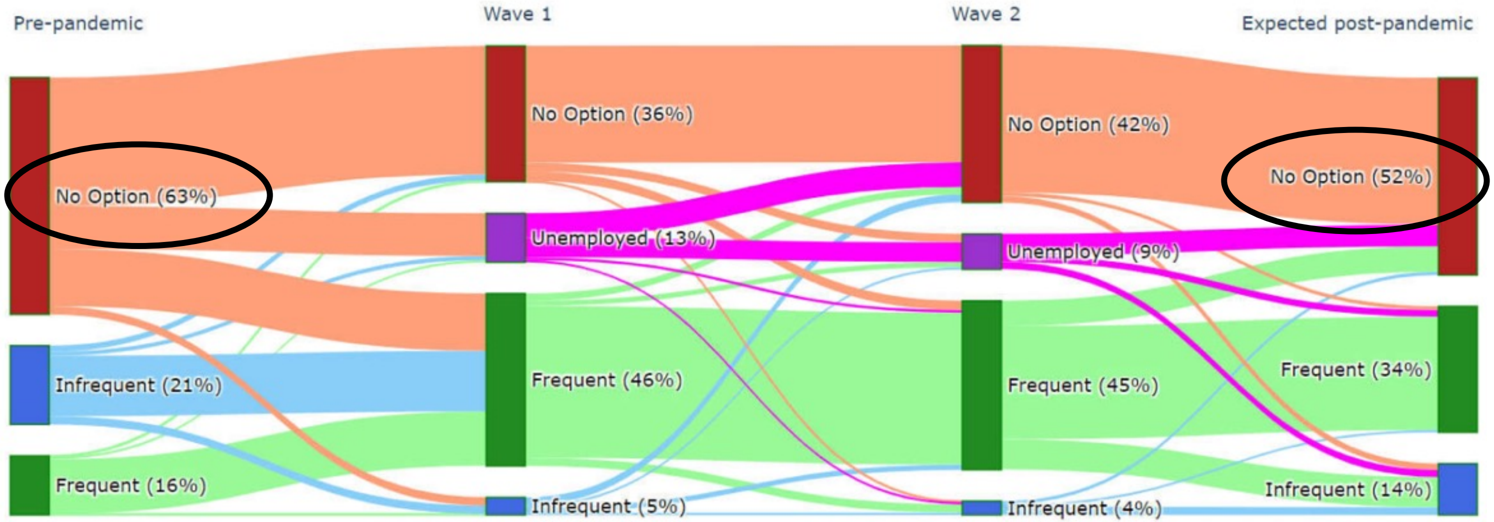
Next, we look at the telecommute frequency before, during and (expected) after COVID-19.

Telecommuting



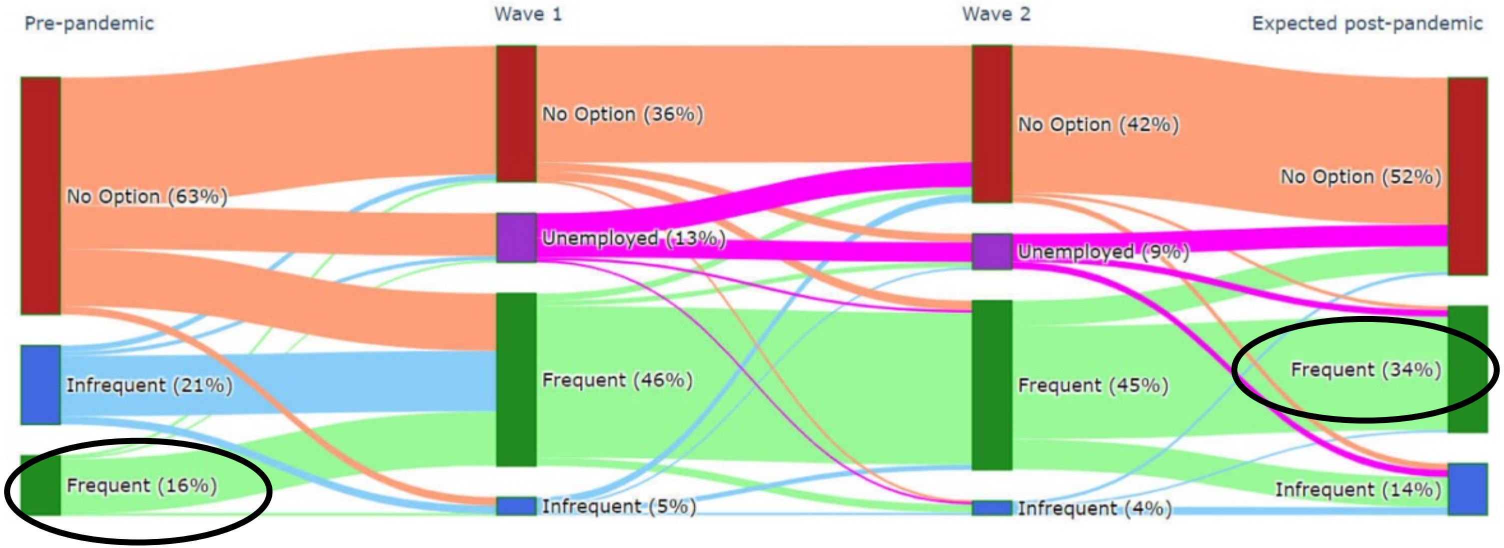
Here 'frequent' refers to telecommuting more than once a week. Whereas, 'infrequent' refers to telecommuting once a week or less.

Telecommuting



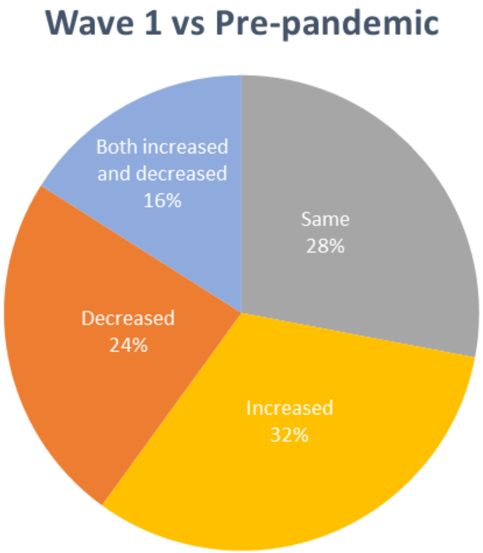
There is an expected 17% reduction in respondents without the option to telecommute post-COVID compared to pre-COVID.

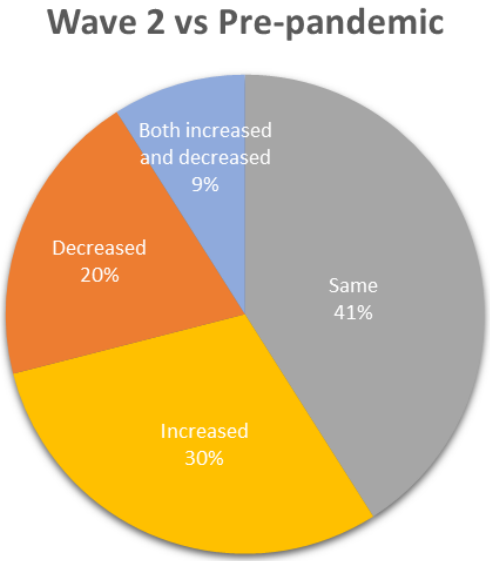
Telecommuting



Frequent commuters' increase from 16% pre-pandemic to 34% in post-pandemic (i.e., 112% growth).

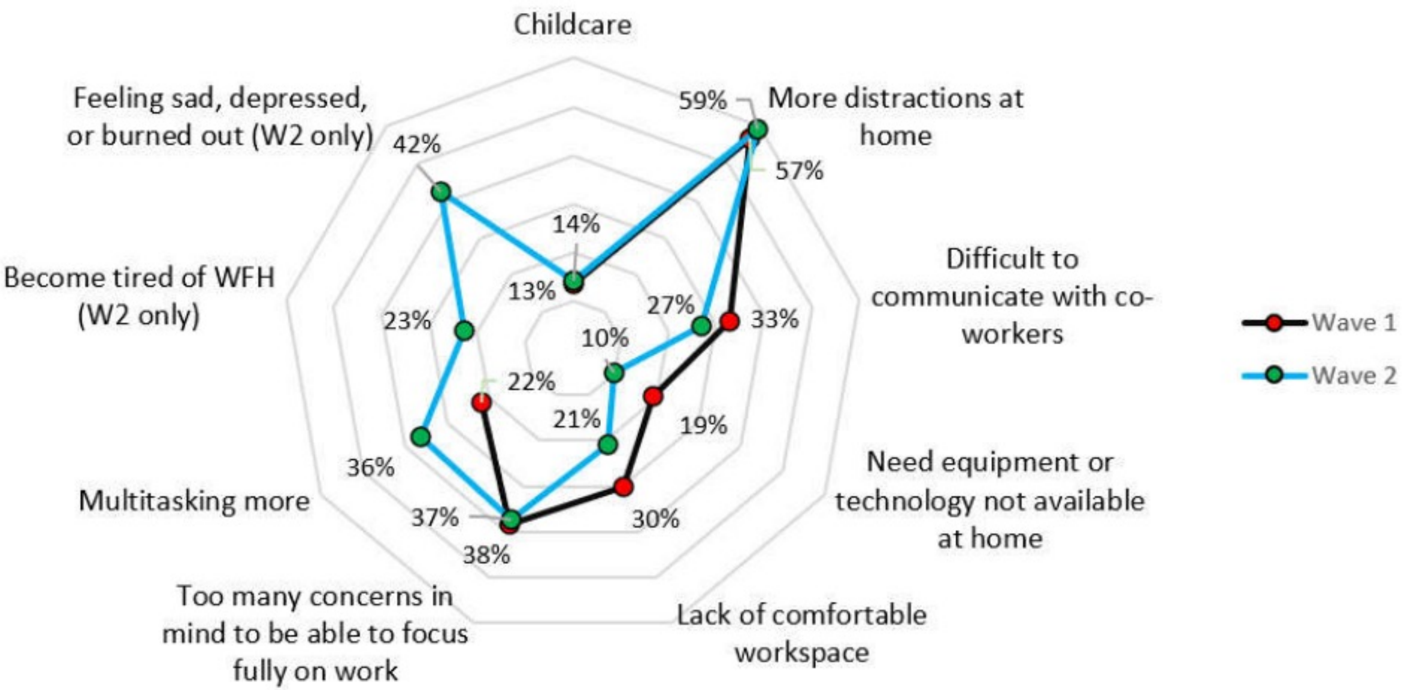
Work Productivity





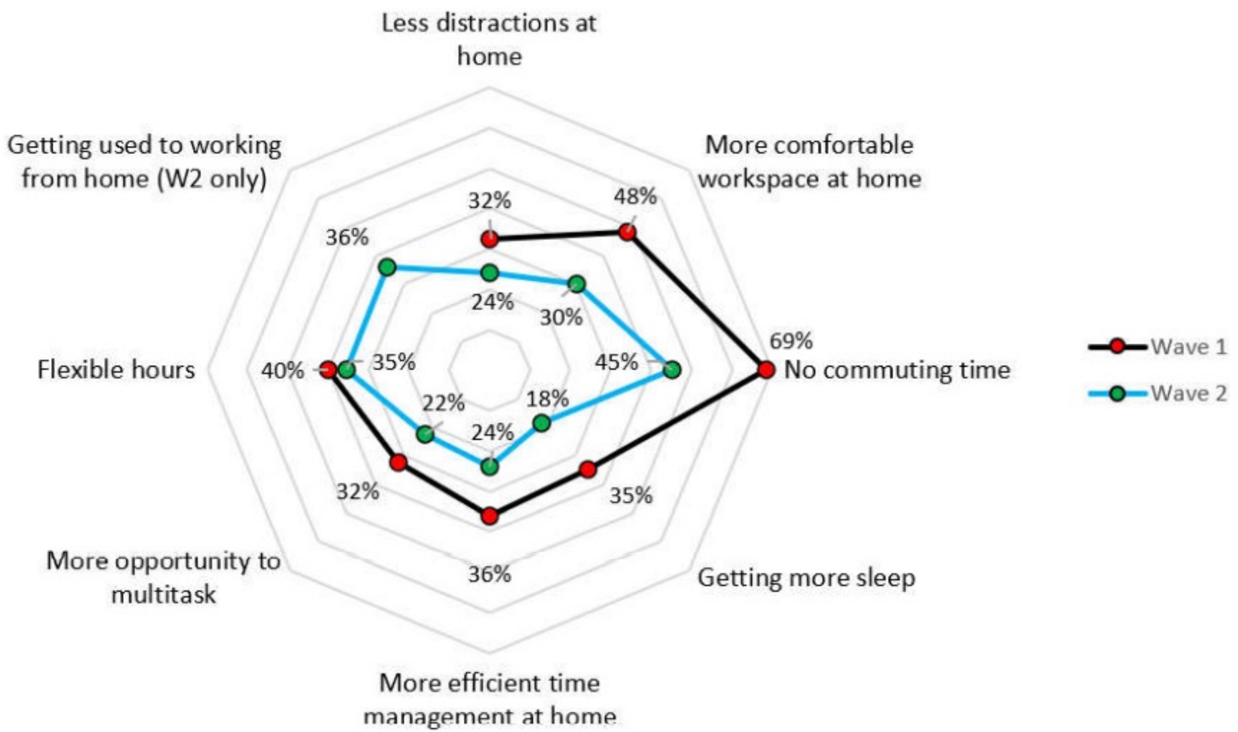
60% of respondents reported that there work productivity increased or remained same in wave 1 (earlier in pandemic). While this percentage increased to 71% in wave 2 (later in pandemic).

Decrease Work Productivity



More distractions at home is the biggest factor in both waves responsible for lower productivity.

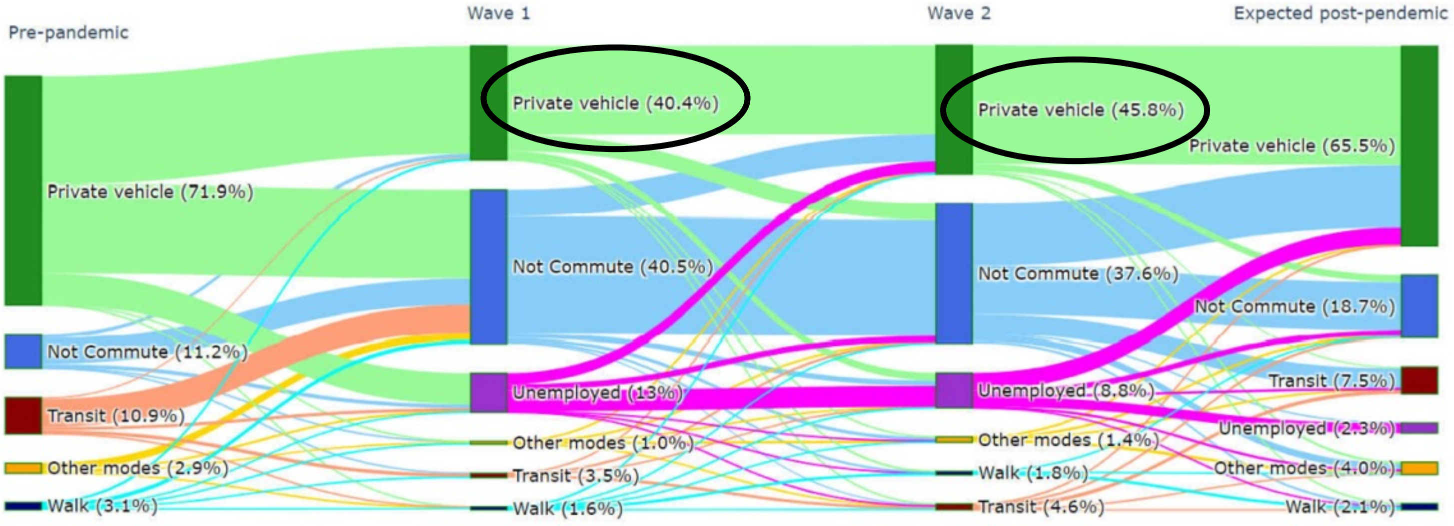
Increase Work Productivity



No commuting time is the biggest factor in both waves responsible for higher productivity.

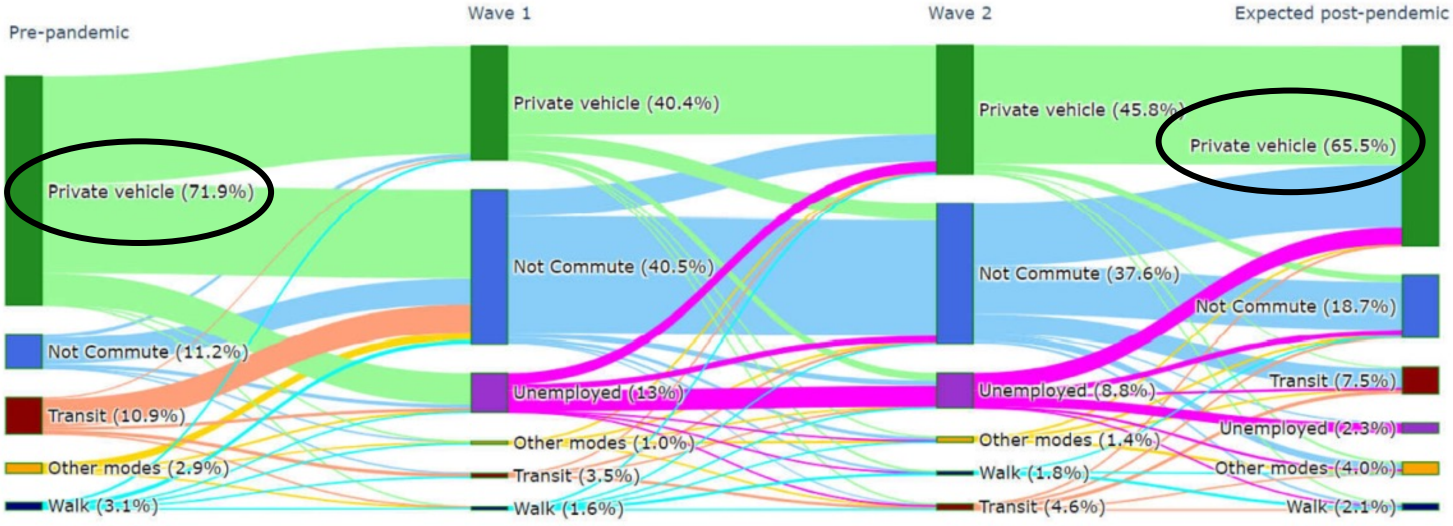
Commuting

Commuting Mode Choice



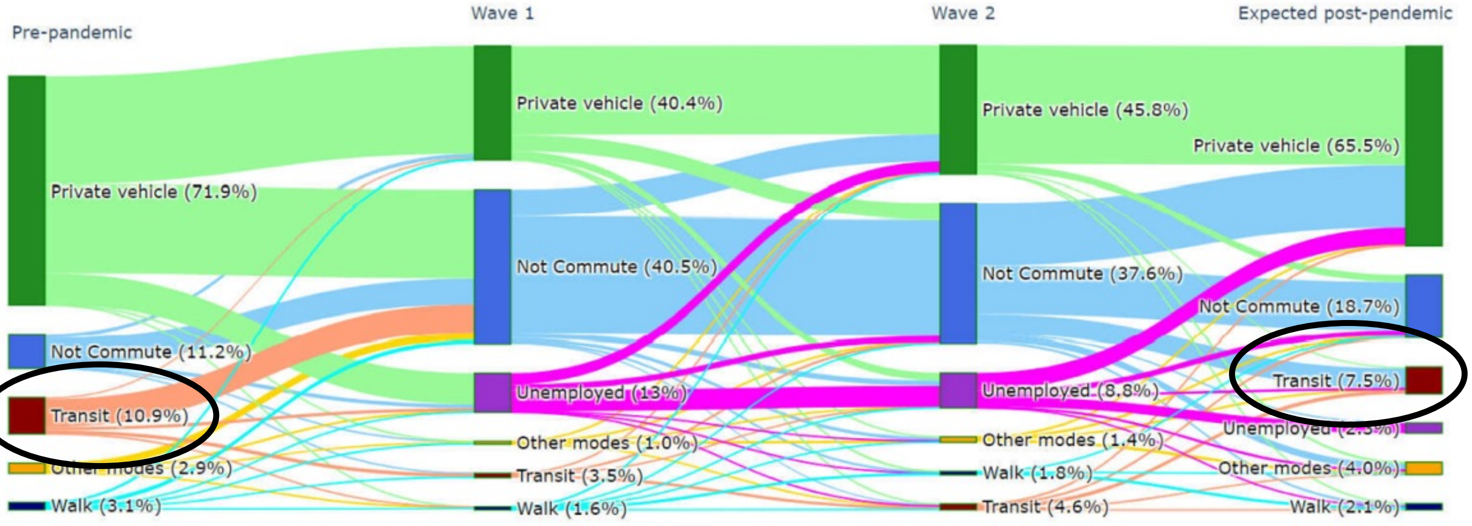
The share of private vehicle commuters plummeted to 40% in wave 1 and remained at around 45% in wave 2.

Commuting Mode Choice



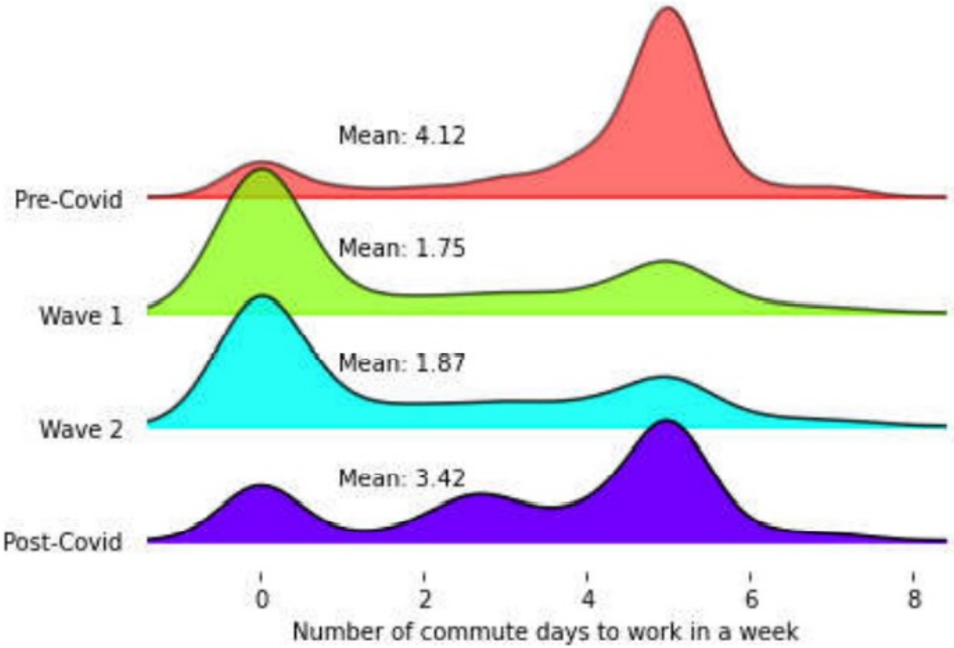
Post-pandemic, only about 66% of the respondents expect to use a private vehicle to commute. While around 19% expect not to commute.

Commuting Mode Choice



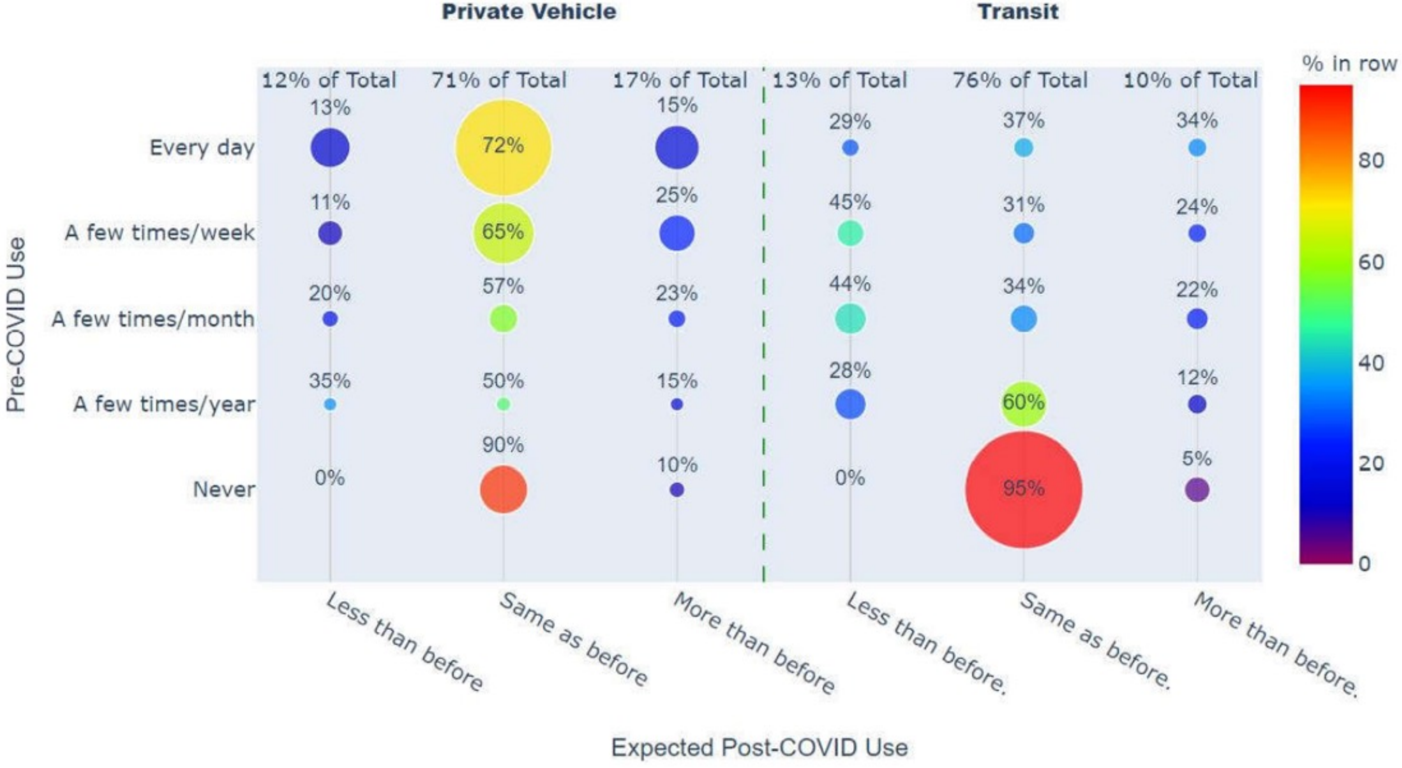
Transit share kept increasing since wave 1 but is still expected to be significantly lower than the pre-pandemic.

Commute Frequency



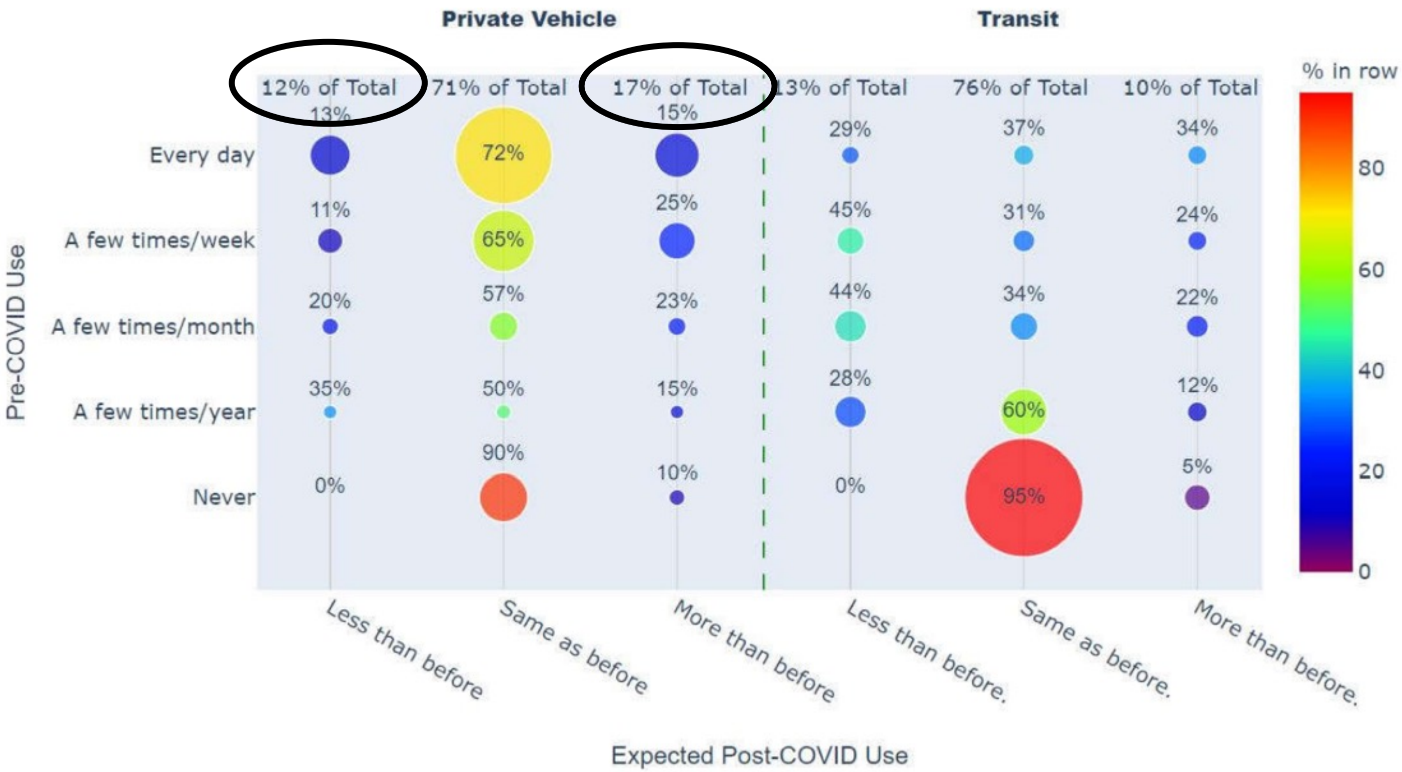
Pre-pandemic, the average number of commute days were 4.1 days/week, which reduced to 1.75 days/week in wave 1 and 1.87 days/week in wave 2. Post-pandemic, it is expected get to 3.42 days/week.

Mode Use Expectation for Post-COVID



Next, we looked at mode use (for all purposes, not just commuting) post-pandemic

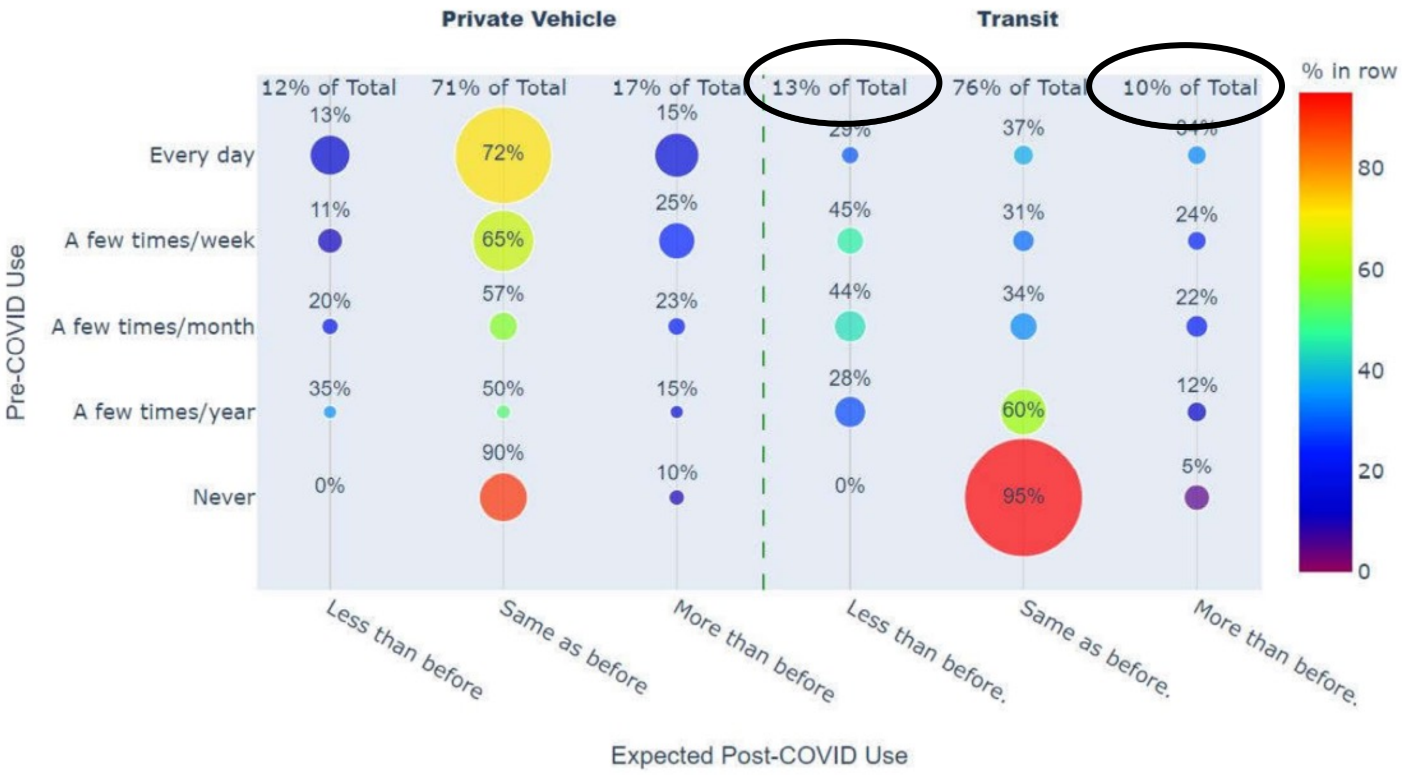
Mode Use Expectation for Post-COVID



12% expect to use private vehicles less than before, whereas 17% expect to use them more.

While the proportion of private vehicle commute trips are expected to decrease, the overall use of private vehicles might increase.

Mode Use Expectation for Post-COVID

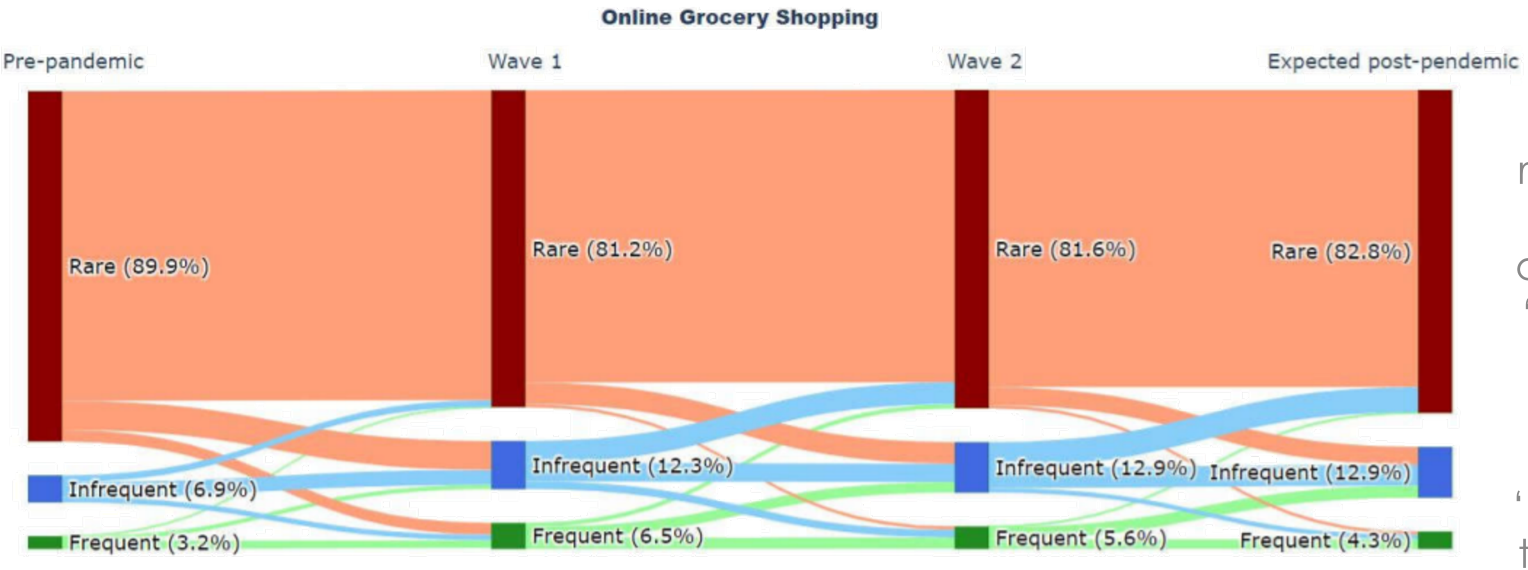


13% expect to use transit less than before, while 10% expect to use transit more than before.

Online Shopping

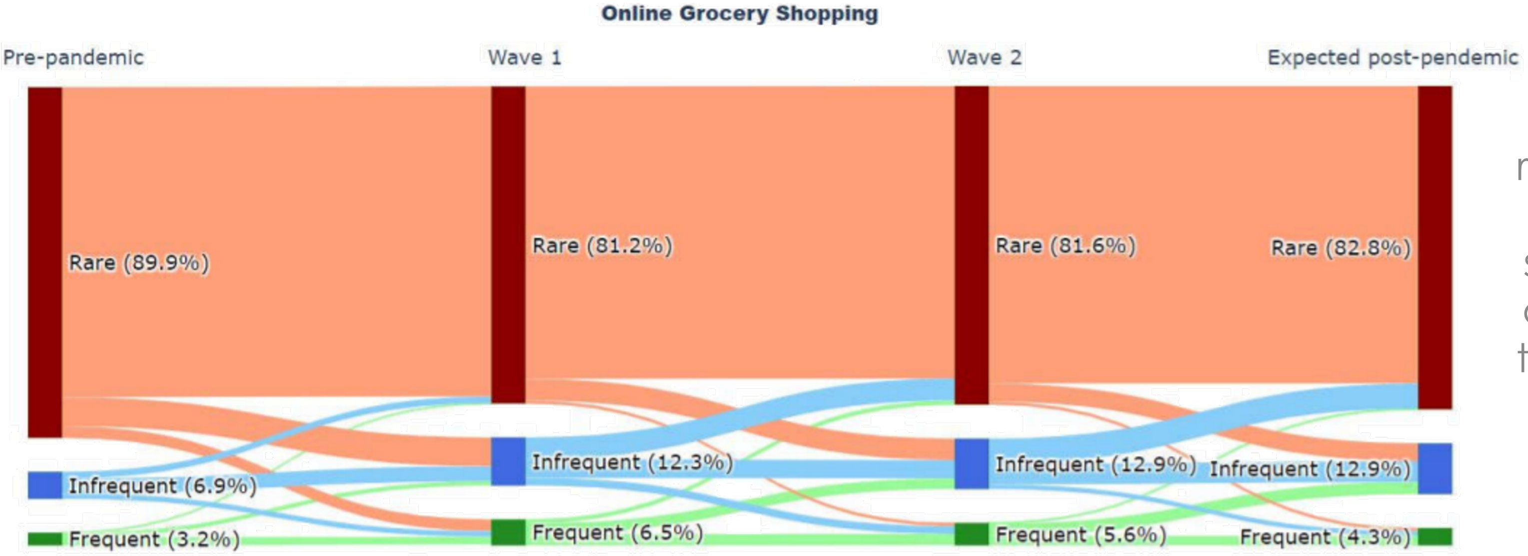
Online Grocery Shopping

Online Grocery Shopping



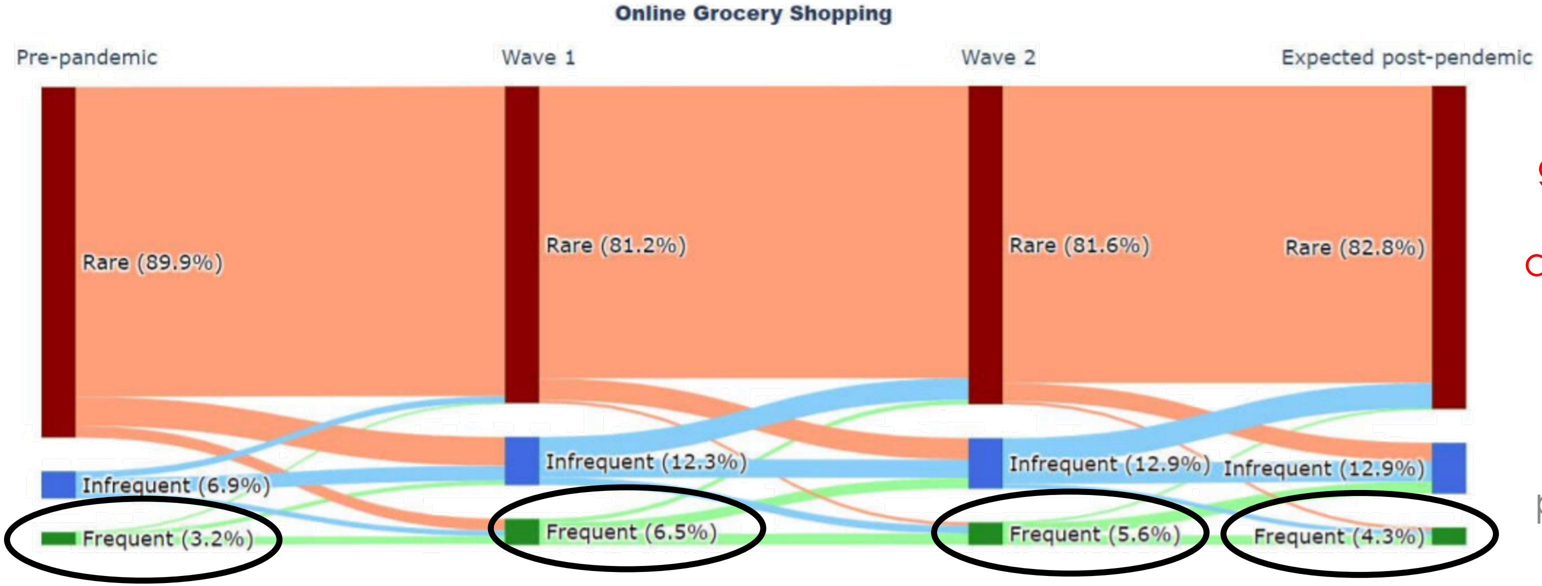
Here 'frequent' refers to shopping more than once/week. While 'infrequent' refers to that between once/week and once/month). 'Rare' refers to less than once/month or never.

Online Grocery Shopping



Over 80% respondents have rarely or never shopped grocery online, neither do they expect to do so after the pandemic.

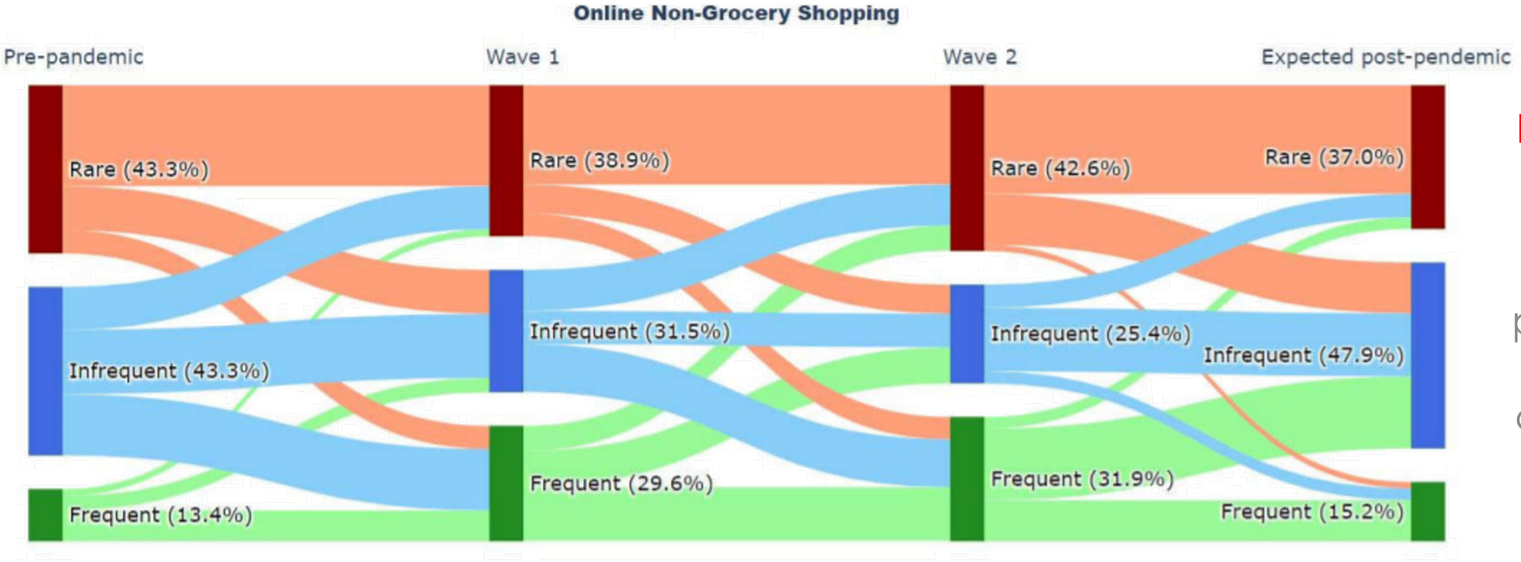
Online Grocery Shopping



Frequent online grocery shoppers have roughly doubled in wave 1 but have slightly decreased in wave 2. A higher percentage of people expect to grocery shop online post-pandemic.

Online Non-Grocery Shopping

Online Non-Grocery Shopping



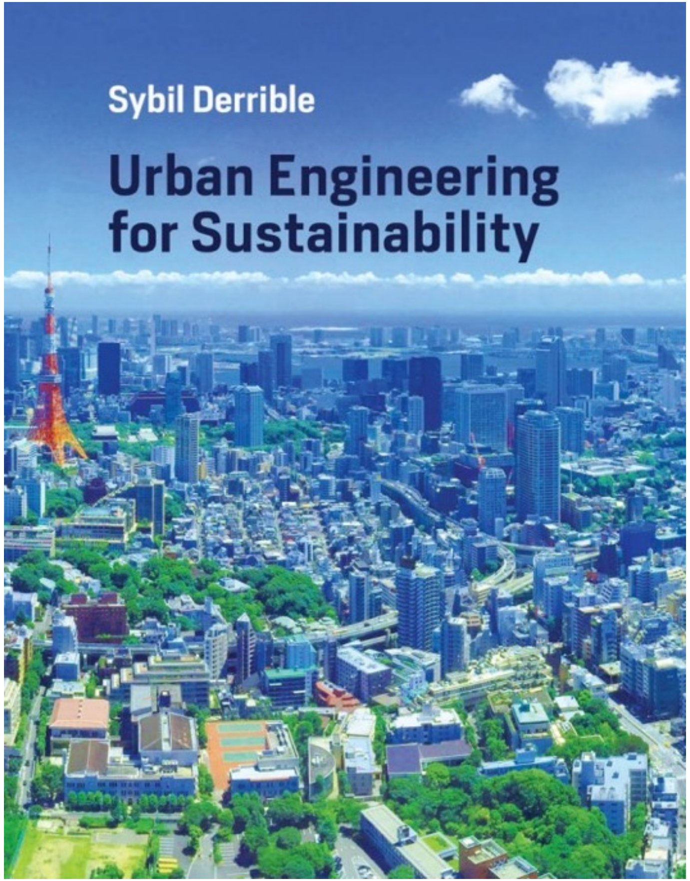
Frequent shoppers more than doubled (+121% growth) from pre-pandemic through wave 1 and continued to grow through wave 2.

Integration with other infrastructure

Urban Infrastructure

	Transport	Water	Utility	Electricity	Telecom	Solid Waste	Buildings
Transport		• Underground water conduits in streets • Leaks and runoff leading to street flooding • Overflowing of stormwater channels leading to flooding	• Underground utility lines in streets • Occasional construction and maintenance of infrastructure leading to traffic disruption	• Raw material transport for electricity generation • Electricity needed for electricity vehicles, electric rail and bus modes and for operations (e.g., traffic signals, street lights)	• Underground telecom lines in streets • Transmission of real-time information	• Bins / cans located on sidewalks, back alleys, roads, etc. • Solid waste collection and transfer vehicles use roads. • Land reclamation create space for transport infrastructure.	• Conflict for land • Buildings as location where people go to or depart from
Water	• Restricted right-of-way • Hard to reach water infrastructure when located underground • Impermeable surfaces leading to flooding		• Competition for underground space • Gas-run pumps for water distribution • Gas leak can contaminate groundwater wells	• Competition for underground space • Electricity to treat and distribute water (Energy-Water Nexus)	• Competition for underground space • Information to manage water distribution systems (e.g., SCADA) • Increasing reliance on telecom with smart meters	• Contamination of surface water bodies and aquifers with incineration and landfilling. • Ability of waste facilities to receive solid waste from treatment plants.	• Force water conduits to be below streets • Impermeable surfaces leading to flooding • Buildings as places of water consumption
Utility	• Restricted right-of-way • Hard to reach gas lines as well as steam and chilled water pipes when located underground	• Competition for underground space		• Competition for underground space	• Competition for underground space • Information transmission for real time monitoring	• Predictable generation of methane for natural gas and district heating systems.	• Buildings as places of gas consumption • Buildings as places of steam and chilled water consumption for space heating
Electricity	• Restricted right-of-way • Hard to reach distribution infrastructure when located underground • Movement of raw material for electricity generation	• Competition for underground space • Thermal power systems require significant amounts of water (Energy-Water Nexus)	• Competition for underground space • Electricity generation from natural gas		• Competition for underground space • Similar to water, increasing reliance on telecom with smart meters	• Predictable generation of electricity. • Ability of waste facilities to receive solid waste from power plants (e.g., nuclear waste).	• Partially directs how distribution lines are installed • Buildings as places of electricity consumption • Hazard with tree branches next to buildings
Telecom	• Restricted right-of-way • Hard to reach telecom lines when located underground • Many Internet cables are located next to rail tracks	• Competition for underground space • Large amounts of water are needed for cooling, especially in data centers •	• Competition for underground space •	• Competition for underground space • All telecom devices require electricity Data centers require a significant amount electricity for cooling		• Ability of waste facilities to receive solid waste from telecom (e.g., wires).	• Buildings as end points where telecom lines are installed
Solid Waste	• Roads must be accessible for solid waste collection and transport vehicles. • Space must be dedicated to solid waste infrastructure	• Some processes require stable supply of water. • Heavy rains to impact landfilling activities. • Facilities use water.	• Natural gas needed to initiate / aid combustion. • Heating / cooling solid waste facilities.	• Some processes require stable supply of electricity (e.g., eddy current separators). Facilities use electricity.	• Environmental monitoring of landfills. • Increasing reliance on telecom (e.g., GPS in garbage trucks)		• Solid waste generated in buildings. • Periodic service of solid waste collection. • Buildings host solid waste facilities.
Buildings	• Conflict for land • Building location (e.g., in real estate)	• Presence / availability of water • Water problems lead to flooding (e.g., basement) • Conflict for land for larger water infrastructure	• Presence / availability of gas • Systems' size for district heating/cooling • Conflict for land for larger gas infrastructure	• Presence / availability of electricity Conflict for land for larger transmission lines	• Presence / availability of telecom lines • Buildings are sometimes strategically located to be near a main telecom hub	• Accommodating solid waste generation (e.g., trash chute, dumpster at back). • Ability of waste facilities to receive solid waste from buildings.	

Urban Engineering for Sustainability



Sybil Derrible

Urban Engineering
for Sustainability

MIT Press

2019

Opportunities?

- Lower energy consumption
- Better monitor road conditions
- Provide better access to fiberoptic Internet
- Improve stormwater management

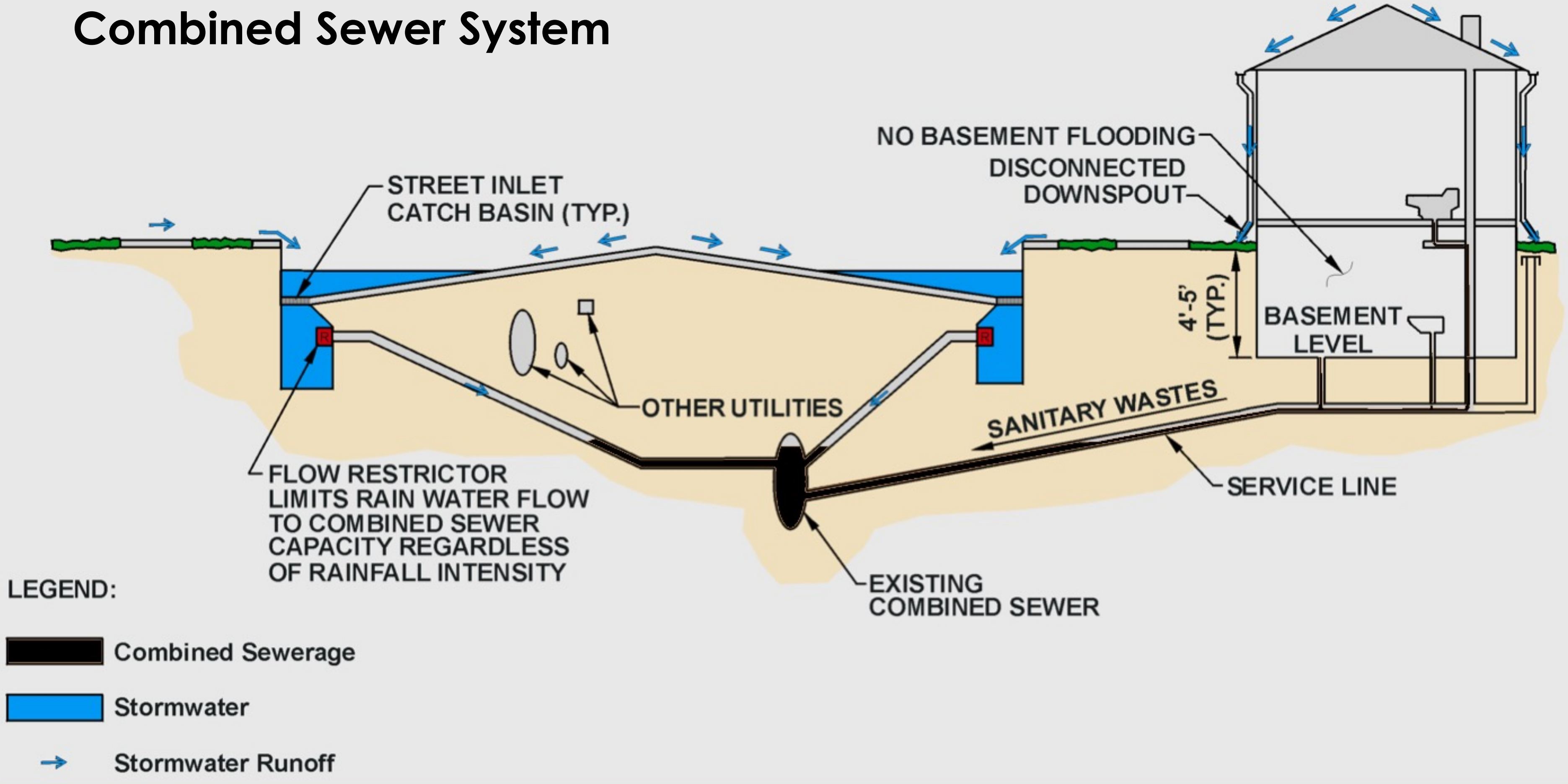
Transforming Cities through Transportation & Stormwater Management

Wastewater

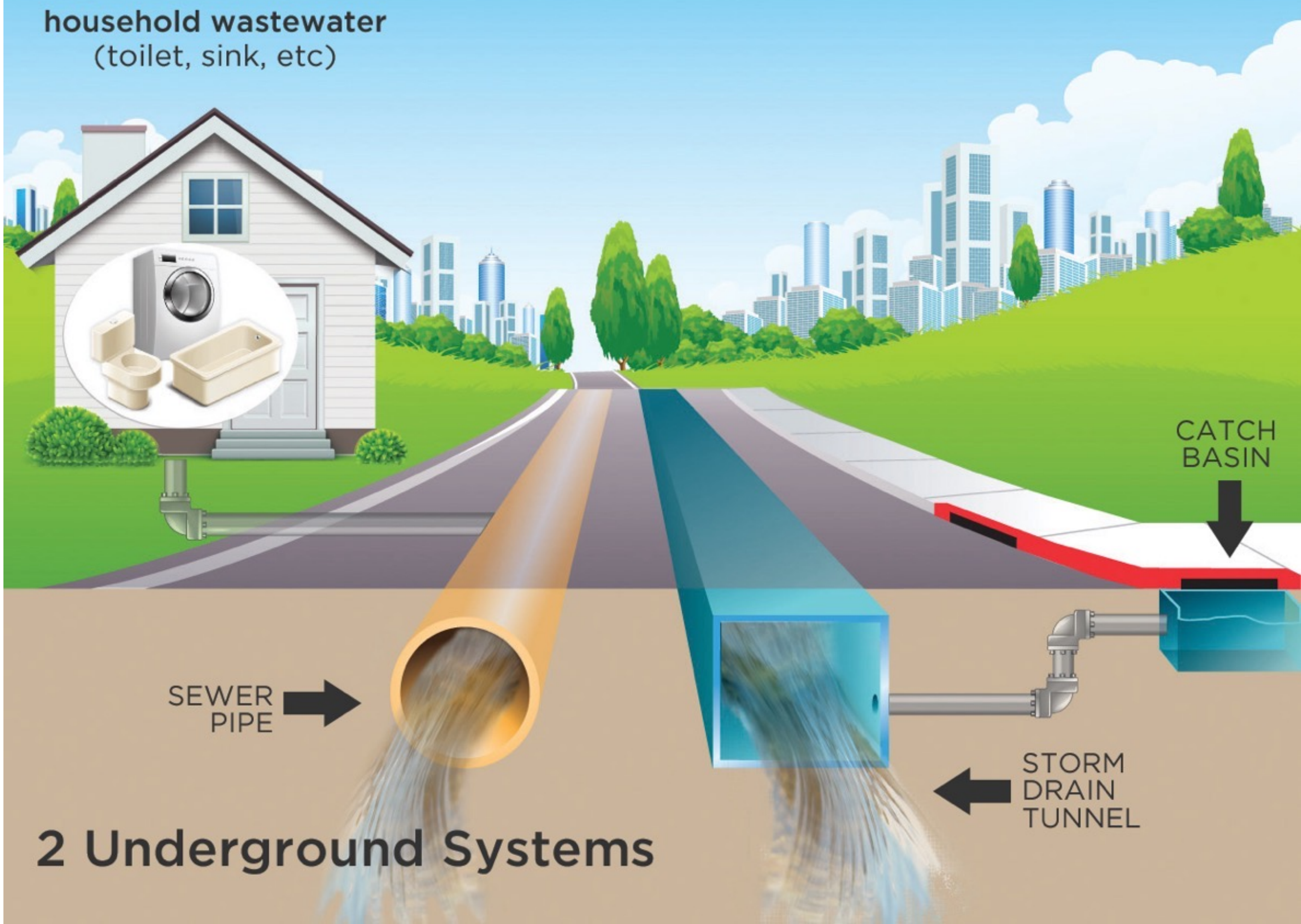
Two Types

1. Sanitary
2. Stormwater

Combined Sewer System



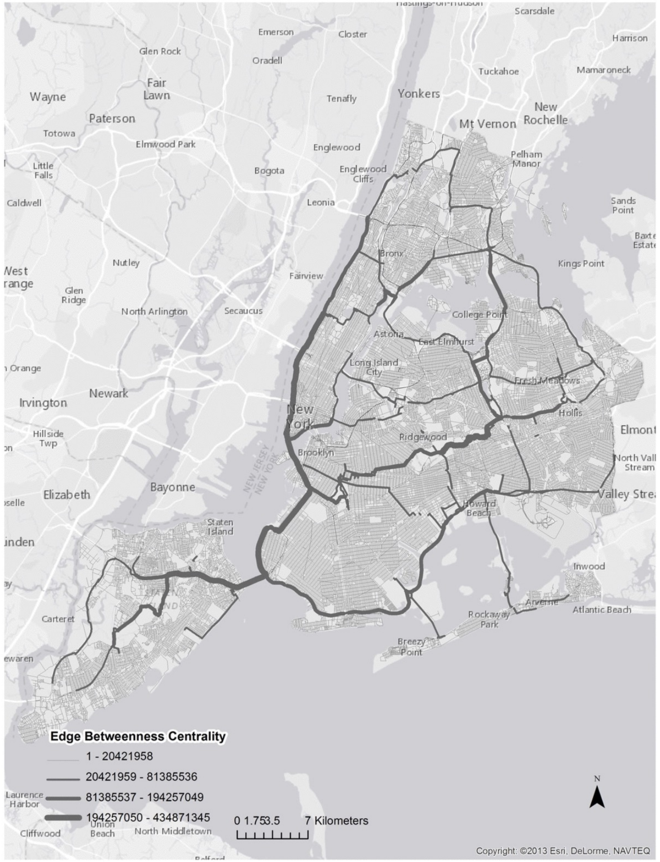
Separate Sewer System

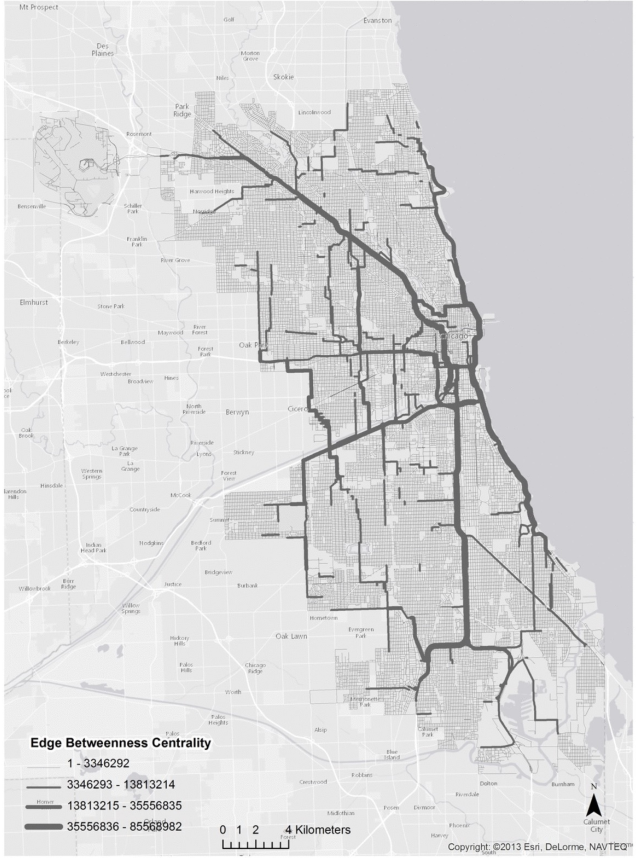



ONE WAY
STOP
Mini THƯƠNG XÁ
MEDICAL CENTER &
CHUYÊN BÁN ĐỦ LOẠI THỰC PHẨM
NHÀ THUỐC TÂY

Road Resilience

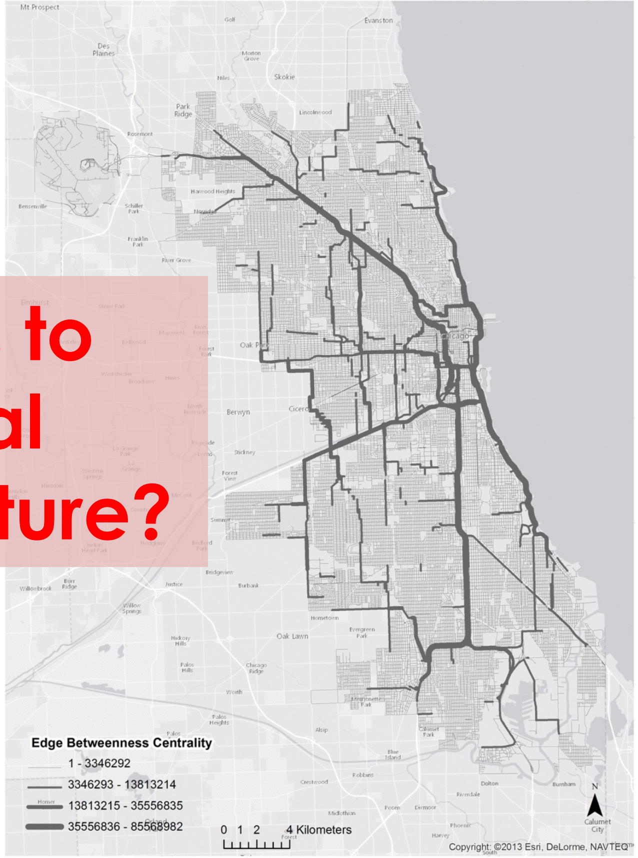
Road Resilience – Flooding





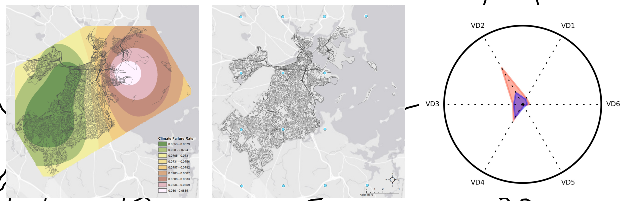
Road Resilience – Flooding

Access to Critical Infrastructure?

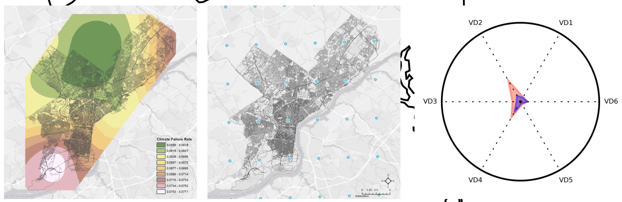


Flash Flood Vulnerability of Five U.S. Cities due to Climate Change

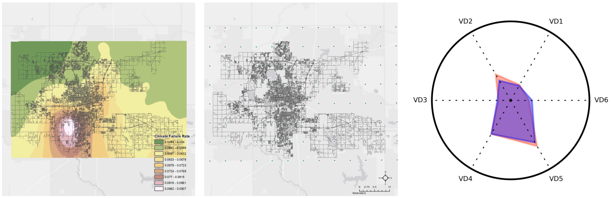
Boston



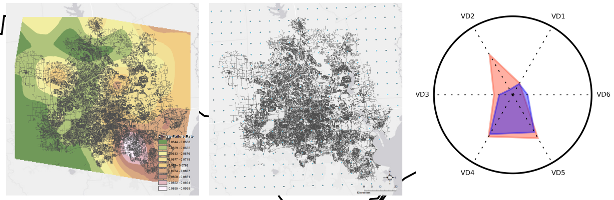
Philadelphia



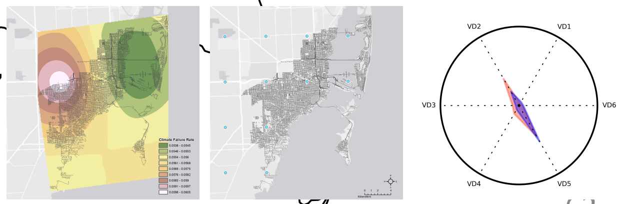
Oklahoma City



Houston



Miami



Flash flood probabiity are simulated using climate models from 2006 to 2100 for two scenarios:

RCP8.5 RCP4.5

Vulnerability is measured by on six dimensions:
VD1: change in the total road network length
VD2: change in maximum edge betweenness centrality
VD3: change in short distance accessibility (1km)
VD4: change in long distance accessibility (5km)
VD5: proportion of trips that cannot be completed
VD6: proportion of completed trips that had to use alternative routes

For more info: Kermanshah et. al, 2017, "Using Climate Models to Estimate Urban Vulnerability to Flash Floods", *Journal of Applied Meteorology and Climatology*, 56, 2637–2650, https://doi.org/10.1175/JAMC-D-17-0083.1

Conclusion

- Many cities in Illinois at depopulating. Join our study!

- COVID-19 is transforming how we live. In particular, more people will more frequently work from home. Transit will need to adapt.

- Transportation is integrated with other infrastructure systems. Make these connections count!

Thank You

Sybil Derrible
(derrible@uic.edu)

Acknowledgements

Illinois Department
of Transportation